MS222E

H-845.D11 Modular Hexapod System

User Manual

Version: 1.1.0 Date: 23.10.2013

This document describes the following product:

- **H-845.D11**
  Modular Hexapod System with Direct Drive, 50 mrad/s, 1000 kg Load, Including Power Supply

PIEZO NANO POSITIONING | WWW.PI.WS

Physik Instrumente (PI) GmbH & Co. KG · Auf der Römerstr. 1 76228 Karlsruhe, Germany
Phone +49 721 4846-0 · Fax +49 721 4846-1019 · E-mail info@pi.ws

Physik Instrumente (PI) GmbH & Co. KG is the owner of the following trademarks:
PI®, PIC®, PICMA®, PILine®, PIFOC®, PiezoWalk®, NEXACT®, NEXLINE®,
NanoCube®, NanoAutomation®, Picoactuator®, PInano®

© 2013 Physik Instrumente (PI) GmbH & Co. KG, Karlsruhe, Deutschland. The text, photographs and drawings in this manual are protected by copyright. With regard thereto, Physik Instrumente (PI) GmbH & Co. KG retains all the rights. Use of said text, photographs and drawings is permitted only in part and only upon citation of the source.

Original instructions
First printing: 23.10.2013
Document number: MS222E, BRo, KSch, Version 1.1.0

Contents

1 About this Document 1

1.1 Goal and Target Audience of this Manual 1
1.2 Symbols and Typographic Conventions 1
1.3 Other Applicable Documents 2

2 Safety 3

2.1 Intended Use 3
2.2 General Safety Instructions 3
2.2.1 Organizational Measures 4
2.2.2 Safety Measures during Transport 4
2.2.3 Safety Measures during Installation 5
2.2.4 Safety Measures during Start-Up 7
2.2.5 Safety Measures during Maintenance 8

3 Product Description 9

3.1 Features and Applications 9
3.2 System Components 9
3.3 Product View 11
3.3.1 Hexapod 11
3.3.2 Hexapod Controller 12
3.3.3 Power Supply of the Hexapod 13
3.4 Scope of Delivery 14
3.5 Technical Features 15
3.5.1 Struts 15
3.5.2 Reference Point Switch and Limit Switches 15
3.5.3 Brakes 15
3.5.4 Control 15
3.5.5 Motion 16

4 Unpacking 21

5 Installation 27

5.1 General Notes on Installation 27
5.2 Determining the Permissible Load and Working Space 29
5.3 Attaching the Snap-On Ferrite Suppressors 30
5.4 Mounting the Hexapod on a Surface 32
5.5 Grounding the Hexapod 35
5.6 Affixing the Load to the Hexapod 35
5.7 Connecting Cable Set and Power Supply to the Hexapod 38

6 Start-Up 41

6.1 General Notes on Start-Up 41
6.2 Starting Up the Hexapod System 43
6.3 Switching Off the Hexapod System 44

7 Maintenance 45

7.1 Carrying out a Maintenance Run 45
7.2 Packing the Hexapod for Transport 46
7.3 Replacing the Fuses of the Hexapod Power Supply 51
7.4 Cleaning the Hexapod 53

8 Troubleshooting 55

9 Customer Service 57

10 Technical Data 59

10.1 Specifications 59
10.1.1 Data Table of Hexapod 59
10.1.2 Maximum Ratings of Hexapod 60
10.1.3 Data Table of Hexapod Power Supply 61
10.1.4 Maximum Ratings of Hexapod Power Supply 61
10.2 Ambient Conditions and Classifications 62
10.2.1 Ambient Conditions and Classifications for Hexapod 62
10.2.2 Ambient Conditions and Classifications for Hexapod Power Supply 63
10.3 Dimensions of the Hexapod 64
10.4 Pin Assignment for Hexapod 67
10.4.1 Power Supply Connection 67
10.4.2 Data Transmission Connection for Brakes, Limit Switches and System Status 67
10.4.3 Data Transmission Connection 68

11 Old Equipment Disposal 71

12 Glossary 73

13 Appendix 77

13.1 Explanations of the Performance Test Sheet 77
13.2 EC Declaration of Conformity 78

1 About this Document

In this Chapter

Goal and Target Audience of this Manual 1
Symbols and Typographic Conventions 1
Other Applicable Documents 2

1.1 Goal and Target Audience of this Manual

This manual contains information on the intended use of the H-845.D11 system.
It provides information about the following items:

- Hexapod mechanics
- Details of the C-887.11 Hexapod controller included in the H-845.D11 system
- Power supply
- Cabling

This manual assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

For general information about the C-887.11 Hexapod controller refer to its separate documentation.

For updated releases of this user manual, or if you have any questions, contact our customer service department (p. 57).

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

CAUTION

Dangerous situation

If not avoided, the dangerous situation will result in injury.

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

If not avoided, the dangerous situation will result in property damage.

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)

1.3 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

For the latest versions of the user manuals contact our customer service department (p. 57).

Description	Document
C-887 Hexapod controller	MS204E User Manual

2 Safety

In this Chapter

Intended Use 3
General Safety Instructions 3

2.1 Intended Use

The modular Hexapod (in short: "Hexapod") is a laboratory device in accordance with DIN EN 61010-1. It is intended to be used in interior spaces and in an environment that is free of dirt, oil and lubricants.

Based on its design and realization, the Hexapod is intended for positioning, adjusting and shifting of loads in six axes at various velocities.

The Hexapod is part of a Hexapod system. The intended use of the Hexapod is only possible in connection with the Hexapod controller, which is part of the Hexapod system and coordinates all motions of the Hexapod, and the Hexapod power supply.

2.2 General Safety Instructions

The H-845.D11 Hexapod system is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the Hexapod system.

- Only use the Hexapod system for its intended purpose, and only use it if it is in a good working order.
- Read the user manuals.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the Hexapod system.

2.2.1 Organizational Measures

User Manual

- Always keep this user manual next to the Hexapod system.
  If the user manual is lost or damaged, contact our customer service department (p. 57).
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can lead to injury as well as property damage.
- Only install and operate the Hexapod system after having read and understood this user manual.

Personnel Qualification

The Hexapod system may only be started up, operated, maintained and cleaned by authorized and qualified staff.

2.2.2 Safety Measures during Transport

There is a risk of injuries caused by crushing since the Hexapod is very heavy and capable of exerting high forces.

- Keep any part of your body away from areas where they can get caught by the Hexapod.

An impermissible mechanical load can damage the Hexapod.

- Only send the Hexapod in the original packaging.
- Only transport the Hexapod using a crane. The crane must lift the Hexapod by 3 ring bolts and shackles affixed to the Hexapod (p. 21).

When the base plate of the Hexapod is affixed to the crane the chains of the crane can cause damage to the Hexapod.

- Only affix the base plate of the Hexapod to the crane with a suitable crane set-up that prevents the chains of the crane from exerting impermissible forces on the Hexapod.
  The chains of the crane must **not** touch the struts and the moving platform of the Hexapod.

2.2.3 Safety Measures during Installation

Depending on the tilting angle of the surface to which the Hexapod is to be mounted, the Hexapod can slip, tilt or fall from the surface. There is a risk of injuries if parts of your body get caught be the Hexapod, and the Hexapod can be damaged.

- Position the surface where the Hexapod is to be mounted horizontally.

If the surface where the Hexapod is to be mounted cannot be positioned horizontally:

- Keep any part of your body away from areas where they can get caught by the Hexapod.
- Disconnect the Hexapod from the crane only when the base plate of the Hexapod is securely affixed to the surface.

Impermissible mechanical load and collisions between the Hexapod, the load to be moved and the environment can damage the Hexapod.

- Only lift and align the Hexapod using a crane. The crane must lift the Hexapod by 3 ring bolts and shackles affixed to the moving platform of the Hexapod (p. 21).
- Hold the Hexapod only by the base plate to position it on a surface.
- Before installing the load, determine the limit value for the load of the Hexapod with a simulation program (p. 29).
- Before installing the load, determine the work space of the Hexapod with a simulation program (p. 29).
- Make sure that the installed load observes the limit value determined with the simulation program.
- Avoid high forces and torques on the moving platform during installation of the Hexapod and the load.
- When the Hexapod is mounted on a tilted surface:
  - Verify that the Hexapod is lifted by the crane without the Hexapod slipping from the tilted surface in a sudden motion.
  - Verify that the chain of the crane remains under slight tension. If the tension is too strong, impermissible forces can be exerted on the Hexapod.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the Hexapod system.

- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.

The Hexapod power supply can be damaged due to disturbed heat dissipation.

- Install the Hexapod power supply only with its bottom side (equipped with rubber feet) facing downwards.
- Place the Hexapod power supply in a location with adequate ventilation to prevent internal heat build-up.
- Allow at least 15 cm clearance from the front and the rear of the unit and 1 cm from the bottom (ensured by the feet of the chassis).
- Never cover any ventilation openings as this will impede ventilation.

When the base plate of the Hexapod is affixed to the crane the chains of the crane can cause damage to the Hexapod.

- Only affix the base plate of the Hexapod to the crane with a suitable crane set-up that prevents the chains of the crane from exerting impermissible forces on the Hexapod.
  The chains of the crane must not touch the struts and the moving platform of the Hexapod.

Incorrect mounting can warp the base plate. Warping of the base plate reduces the accuracy.

- Mount the Hexapod on an even surface. The recommended evenness of the surface is 100 µm.

The Hexapod can be damaged by excessively long screws.

- When selecting the screw length, observe the thickness of the moving platform (p. 64) or the depth of the mounting holes together with the load to be mounted.
- Only use screws that do not project under the moving platform after being screwed in.
- Only mount the Hexapod and a load on the mounting fixtures (holes) intended for this purpose.

2.2.4 Safety Measures during Start-Up

There is a risk of injuries caused by crushing which can occur between the moving parts of the Hexapod and a stationary part or obstacle.

- ➢ Keep any part of your body away from areas where they can get caught by moving parts.

The Hexapod controller checks if the output voltage of the Hexapod power supply is in the permissible range. When the output voltage exceeds the upper limit of the permissible range, the struts of the Hexapod can be damaged.

Exceeding the upper limit of the permissible output voltage range is indicated as follows:

- The Hexapod controller beeps constantly.
- An error code is set.
- The **Status** LED of the Hexapod glows red.

- ➢ When the permissible output voltage range is exceeded, switch off the Hexapod power supply immediately and contact our customer service department (p. 57).

The geometrical data used by the Hexapod controller must be adapted to the Hexapod. If incorrect geometrical data is used, the Hexapod can be damaged by uncontrolled motions or collisions. The geometrical data is adapted before delivery.

- ➢ Check whether the Hexapod controller matches the Hexapod.
  A label on the rear panel of the controller indicates for which Hexapod the controller is intended.
- ➢ Use the `CST?` command to query for the active Hexapod geometry file (see user manual of the Hexapod controller). Thus you can check if the label on the rear panel is still correct.
- ➢ Only operate the Hexapod with a Hexapod controller whose geometrical data is adapted to the Hexapod.

Collisions can damage the Hexapod, the load to be moved, and the surroundings.

- ➢ Make sure that no collisions between the Hexapod, the load to be moved, and the surroundings are possible in the working space of the Hexapod.
- ➢ Do not place any objects in areas where they can get caught by moving parts.
- ➢ Immediately stop the motion if a malfunction occurs in the Hexapod controller (see user manual of the Hexapod controller).

2.2.5 Safety Measures during Maintenance

The Hexapod can become misaligned as a result of improper maintenance. The specifications (p. 59) can change as a result.

- Do not loosen any screws.

3 Product Description

In this Chapter

Features and Applications 9
System Components 9
Product View 11
Scope of Delivery 14
Technical Features 15

3.1 Features and Applications

The Hexapod offers a maximum velocity of up to 20 mm/s and 50 mrad/s. The load capacity of the Hexapod achieves 1000 kg with the Hexapod base plate mounted horizontally.

The parallel kinematics structure and the free choice of the pivot point offer the following advantages:

- Positioning operations in six independent axes (three translation axes, three rotation axes) with short settling times
- Pivot point is maintained for rotations and moves along with linear motions
- High accuracy and step resolution in all axes
- No addition of the errors of individual axes
- No friction and torques from moving cables

The Hexapod is controlled with the Hexapod controller, which is delivered with the Hexapod. The position commands to the Hexapod controller are entered in Cartesian coordinates.

3.2 System Components

The Hexapod is delivered together with a Hexapod controller, a power supply and a cable set.

Components of the H-845.D11 Hexapod system

Model	Name
H845B0008	Modular Hexapod with direct drive, 50 mrad/s, 1000 kg load
C-887.11	6-D Hexapod controller, control of 2 additional servo-motor axes included, TCP/IP and RS-232 interface, 19'' chassis, with additional I/O bracket
M850B0384	Power supply of the Hexapod, 110 – 230 V / 24 V, 700 VA, 1 sub-D3W3f connector
3763	2 Power cords for power supply of Hexapod and for Hexapod controller
K040B0088	Data transmission cable, MDR68m to MDR68m, 1:1, 9 m
K060B0140	Power supply cable, sub-D3W3m to sub-D3W3f, 1:1, 3 m
K040B0430	Data transmission cable for brakes, limit switches and system status, sub-D25m to sub-D25f, 1:1, 9 m
000045400	2 Laird snap-on ferrite suppressors

3.3 Product View

3.3.1 Hexapod

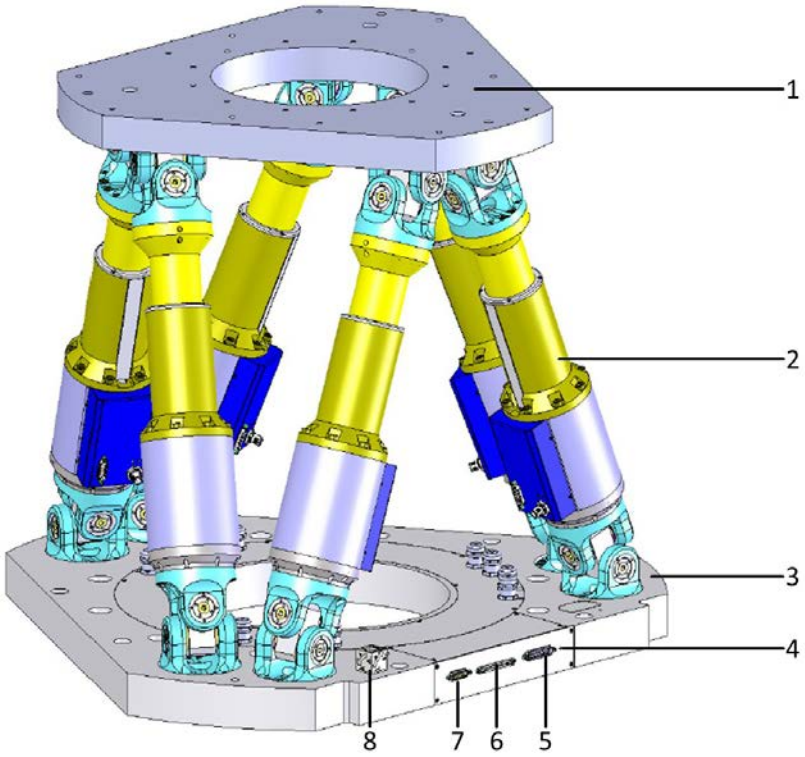


Figure 1: H845B0008 Hexapod

1 *Moving platform*
2 *Strut*
3 *Base plate*
4 *Status LED (Status), details see below*
5 *Panel plug for data transmission cable (Digital I/O: signals of brakes, limit switches, system status)*
6 *Socket for data transmission cable (Controller: encoder signals)*
7 *Panel plug for power supply cable (24 VDC)*
8 *Cube describing the orientation of the coordinate system*

Figure 2: Connections and status LED at base plate of the Hexapod

The **Status** LED indicates the following states:

- Ready:
  Permanent green glow, commanded moves are performed
- Not ready:
  Permanent red glow, commanded moves are not performed.

Refer to “Troubleshooting” on p. 55 for more information.

3.3.2 Hexapod Controller

General information including details of front and rear panel of the C-887 Hexapod controller is given in the MS204E user manual.

The Hexapod controller included in the H-845.D11 Hexapod system differs from the standard C-887 Hexapod controllers in featuring an additional sub-D 25 (f) I/O interface as labeled in Figure 3. For more information refer to “Control” on p. 15.

Figure 3: Rear view of the Hexapod controller included in the H-845.D11 modular Hexapod system

3.3.3 Power Supply of the Hexapod

Figure 4: Front panel of power supply

1 Power LED (Power)

Figure 5: Rear panel of power supply

1. Fuse carrier for two fuses with IEC rating T8AL

2 Power switch:
position: power supply is switched off
position: power supply is switched on

3 Panel plug, male, for line cord

4 Power LED (Power)

5 Fan

6 Sub-D3W3 socket (Power Out 1) for 24 V DC output

3.4 Scope of Delivery

The following table contains the scope of delivery of the Hexapod.

The scope of delivery of the Hexapod controller is listed in the user manual of the Hexapod controller.

For the scope of delivery of the cable set that belongs to the Hexapod system and the Hexapod power supply, see "System Components" (p. 9).

Order Number	Items
H845B0008	Hexapod mechanics of the system, including: ▪ 6 hex-head cap screws M12x60 ISO 4762 (for mounting the base plate)
000045400	2 Laird snap-on ferrite suppressors
Packaging, consisting of:	
M850B0436	Packaging materials: ▪ Pallet, 880 mm x 800 mm x 162 mm ▪ Cardboard box, lower part, 842 mm x 762 mm x 815 mm ▪ Cardboard box, upper part, 870 mm x 790 mm x 120 mm ▪ Compound foil, 800 mm x 800 mm x 1200 mm ▪ Hard foam insert for moving platform of Hexapod, 840 mm x 760 mm x 100 mm ▪ Hard foam insert for base plate of Hexapod, 840 mm x 760 mm x 100 mm
Documentation, consisting of:	
H845T0001	Technical note in printed form on unpacking the Hexapod
MS222E	User manual for the Hexapod system (this document)
Screw sets:	
000039812	Mounting accessories: ▪ 1 Allen wrench 10.0 DIN 911
000036450	Accessories for connection to the grounding system: ▪ 1 flat-head screw with cross recess M4x8 ISO 7045 ▪ 2 washers, form A-4.3 DIN 7090 ▪ 2 safety washers, Schnorr Ø 4 mm N0110

3.5 Technical Features

3.5.1 Struts

The Hexapod has six adjustable-length struts. Each strut carries out linear motions. Each set of settings of the six struts defines a position of the moving platform in six degrees of freedom (three translation axes and three rotation axes).

Each strut is equipped with the following components:

- One actuator
- Reference and limit switches
- Joints for connecting to the base plate and moving platform

The actuator contains the following components:

- Brushless DC motor with rotary encoder
- Brake
- Drive screw

3.5.2 Reference Point Switch and Limit Switches

The reference point switch of a strut functions independently of the angular positions of the strut ends and the lengths of the other struts.

When a limit switch is activated, the power source of the motor is switched off to protect the Hexapod against damage from malfunctions.

3.5.3 Brakes

The brakes of the struts are activated by default. The brakes are deactivated only when the servo mode is switched on for the axes of the moving platform. For more information refer to “Starting Up the Hexapod System” on p. 43.

3.5.4 Control

The Hexapod is intended for operation with the Hexapod controller which is delivered with the Hexapod. The Hexapod controller makes it possible to command motion of individual axes, combinations of axes or all six axes at the same time in a single motion command.

The Hexapod controller calculates the settings for the individual struts from the target positions given for the translation and rotation axes. The velocities and accelerations of the struts are calculated in such a way that all struts start and stop at the same time.

After the Hexapod controller has been switched on or restarted, the Hexapod has to complete a reference move in which each strut moves to its reference point switch. After the reference move, the moving platform is in the reference position and can be commanded to move to absolute target positions.

Differing from the standard controller, the delivered Hexapod controller is equipped with an additional **I/O** sub-D25 (f) socket. The **I/O** socket carries lines for brakes, limit switches and system status which are used for the following additional functions:

- System status display via the **Status** LED (at the base plate of the Hexapod, p. 11)
- Brake activation or deactivation depending on the current servo mode (p. 43)
- Check if the output voltage of the external power supply is out of the required range (low limit of output voltage is checked only when servo mode is on)
- Limit switch check

For more information, see “Troubleshooting” on p. 55 and the user manual of the Hexapod controller.

3.5.5 Motion

The platform moves along the translation axes X, Y and Z and around the rotation axes U, V and W.

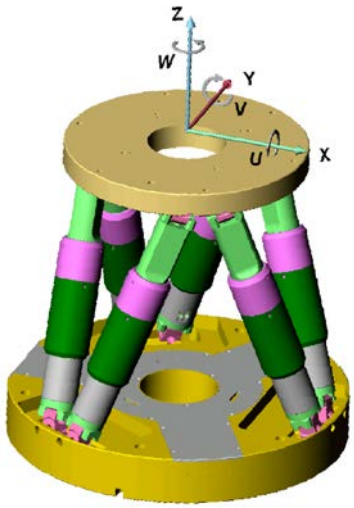


Figure 6: XYZ coordinate system and rotations to the rotation coordinates U, V and W. The coordinate system is depicted above the platform for better clarity.

Translation

Translations take place in the spatially fixed XYZ coordinate system. The translation axes meet at the origin of the XYZ coordinate system (0,0,0). For more information, see the glossary (p. 73).

Rotation

Rotations take place around the rotation axes U, V and W. The rotation axes meet at the pivot point. Further information on the pivot point is found in the glossary (p. 73).

In contrast to the spatially fixed translation axes, the rotation axes and thus the pivot point as well move along with the platform; see also the example below for consecutive rotations.

A given rotation in space is calculated from the individual rotations in the sequence U > V > W.

INFORMATION

The dimensional drawing (p. 64) contains the following:

- Alignment of the XYZ coordinate system
- Position of the pivot point after the reference move, when the standard settings of the Hexapod controller are used

Example: Consecutive rotations

INFORMATION

For a clearer view, the figures have been adapted as follows:

- Round platform replaced by T-shaped platform
- XYZ coordinate system shown shifted
- Pivot point in the top left corner of the platform

1. The U axis is commanded to move to position 10.

   The rotation around the U axis tilts the rotation axes V and W.

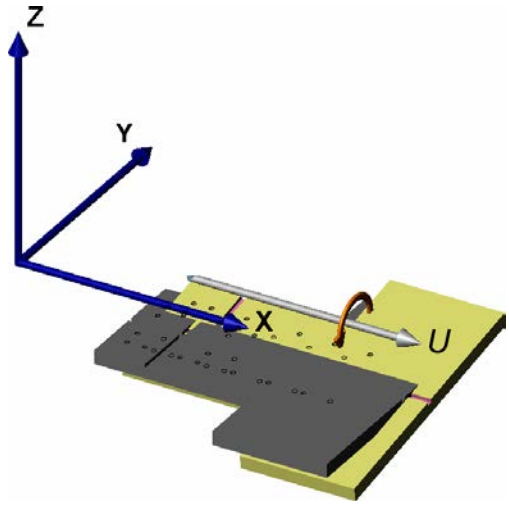


Figure 7: Rotation around the U axis

- Platform in reference position
- Platform position: U = 10 (U parallel to spatially fixed X axis)

2. The V axis is commanded to move to position –10.

   The rotation takes place around rotation axis V, which was tilted during the previous rotation.

   The rotation around the V axis tilts the rotation axes U and W.

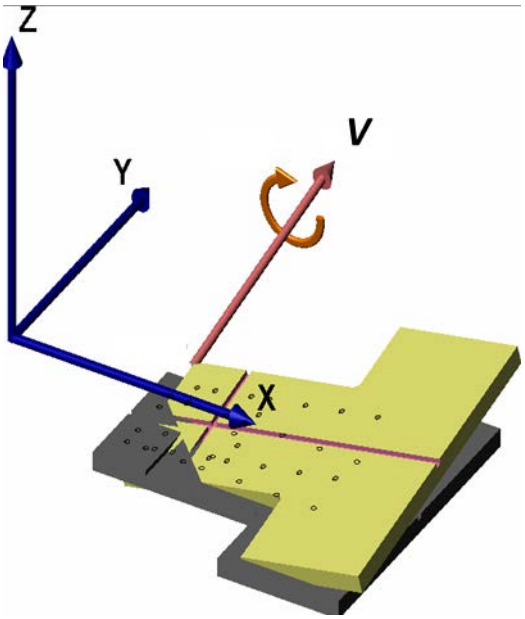


Figure 8: Rotation around the V axis

Platform in reference position

Platform position: U = 10, V = –10 (U and V parallel to the platform level)

3. The W axis is commanded to move to position 10.

   The rotation takes place around the rotation axis W, which was tilted during the previous rotations. The W axis is always vertical to the platform level.

   The rotation around the W axis tilts the rotation axes U and V.

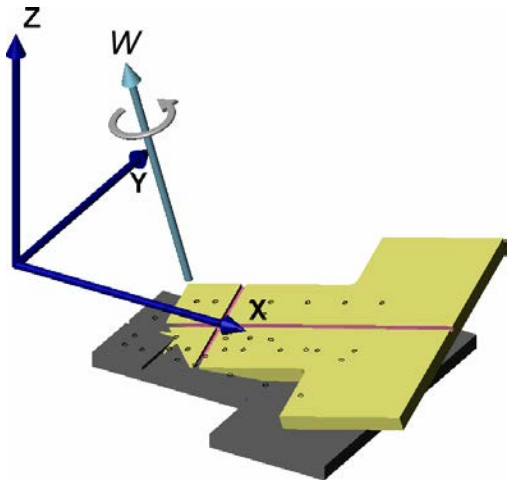


Figure 9: Rotation around the W axis

Platform in reference position

Platform position: U = 10, V = –10, W = 10 (U and V parallel to the platform level, W vertical to the platform level)

For more data on the travel ranges, see the "Specifications" (p. 59) section .

4 Unpacking

The Hexapod is delivered in a special packaging with adapted foam inserts.

CAUTION

Risk of crushing!

There is a risk of injuries caused by crushing since the Hexapod is very heavy and capable of exerting high forces.

- ➢ Keep any part of your body away from areas where they can get caught by the Hexapod.

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the Hexapod.

- ➢ Only send the Hexapod in the original packaging.
- ➢ Only transport the Hexapod using a crane. The crane must lift the Hexapod by 3 ring bolts and shackles affixed to the Hexapod.
  You have two options to fix the ring bolts and shackles:
  - Recommended:
    Use the 3xM12 mounting holes with a depth of 24 mm of the moving platform of the Hexapod as labeled in Figure 14 on p. 24.
  - Use the 3xM12 mounting holes with a depth of 50 mm of the base plate of the Hexapod, see Figure 31 on p. 66.

NOTICE

With base plate affixing to crane: Damage due to chains of crane!

When the base plate of the Hexapod is affixed to the crane the chains of the crane can cause damage to the Hexapod.

- ➢ Only affix the base plate of the Hexapod to the crane with a suitable crane set-up that prevents the chains of the crane from exerting impermissible forces on the Hexapod.
  The chains of the crane must **not** touch the struts and the moving platform of the Hexapod.

Accessories

- 3 ring bolts of appropriate size
- 3 shackles of appropriate size
- Crane appropriate to carry a load of 120 kg

Unpacking the Hexapod

Figure 10: Hexapod package as delivered, with lid cardboard removed

1. Open the cardboard box, see figure above.

Figure 11: Hexapod package with upper hard foam insert removed

2. Remove the hard foam insert from the moving platform, see figure above.

Figure 12: Hexapod package with surrounding cardboard box removed

3. Remove the cardboard box that surrounds the Hexapod, see figure above.

Figure 13: Unwrapped Hexapod, keep the foil for repacking

4. Remove the compound foil that the Hexapod is wrapped in.
   Remove the foil in a way that allows a future repacking of the Hexapod.

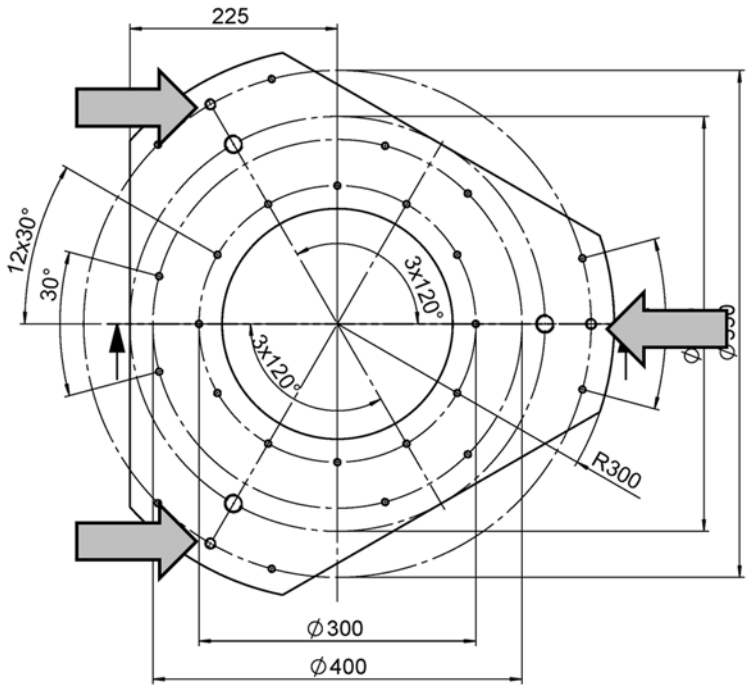


Figure 14: Top view on Hexapod, the arrows mark the three M12 mounting holes with 24 mm depth to be used for transport

5. Fix three ring bolts to the three M12 mounting holes with 24 mm depth in the moving platform of the Hexapod, see Figure 14.
6. Connect each ring bolt with a shackle.

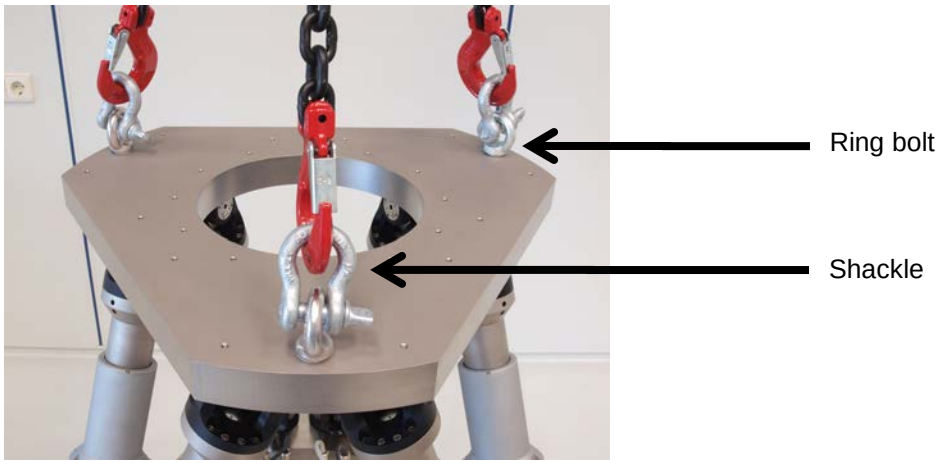


Figure 15: Lifting the Hexapod at its moving platform using three ring bolts and three shackles

7. Connect the shackles to the corresponding load interfaces of the crane, see figure above.

Figure 16: Lifting the Hexapod by a crane

8. Lift the Hexapod out of the cardboard box.
9. Remove the hard foam insert from the base plate of the Hexapod.
10. Compare the contents against the items covered by the contract and against the packing list. If parts are incorrectly supplied or missing, contact PI immediately.
11. Inspect the Hexapod for signs of damage. If you notice signs of damage, contact PI immediately.
12. Keep all packaging materials in case the product needs to be transported again later.

5 Installation

In this Chapter

General Notes on Installation 27
Determining the Permissible Load and Working Space 29
Attaching the Snap-On Ferrite Suppressors 30
Mounting the Hexapod on a Surface 32
Grounding the Hexapod 35
Affixing the Load to the Hexapod 35
Connecting the Cable Set to the Hexapod 38

5.1 General Notes on Installation

The Hexapod can be mounted in any orientation.

CAUTION

Crushing hazard!

Depending on the tilting angle of the surface to which the Hexapod is to be mounted, the Hexapod can slip, tilt or fall from the surface. There is a risk of injuries if parts of your body get caught be the Hexapod, and the Hexapod can be damaged.

- ➢ Position the surface where the Hexapod is to be mounted horizontally.

If the surface where the Hexapod is to be mounted cannot be positioned horizontally:

- ➢ Keep any part of your body away from areas where they can get caught by the Hexapod.
- ➢ Disconnect the Hexapod from the crane only when the base plate of the Hexapod is securely affixed to the surface.

NOTICE

Impermissible mechanical load and collisions!

Impermissible mechanical load and collisions between the Hexapod, the load to be moved and the environment can damage the Hexapod.

- Only lift the Hexapod using a crane. The crane must lift the Hexapod by 3 ring bolts and shackles affixed to the moving platform of the Hexapod, see Figure 16 on p. 25.
- Before installing the load, determine the limit value for the load of the Hexapod with a simulation program (p. 29).
  The limit values determined with the simulation program are only valid when the Hexapod controller has the servo mode switched on for the axes of the moving platform of the connected Hexapod.
- Before installing the load, determine the working space of the Hexapod with a simulation program (p. 29).
  The limits of the working space vary depending on the current position of the Hexapod (translation and rotation coordinates) and the current coordinates of the pivot point.
- Avoid high forces and torques on the moving platform during installation.
- When the Hexapod is mounted on a tilted surface:
  - Verify that the Hexapod is lifted by the crane without the Hexapod slipping from the tilted surface in a sudden motion.
  - Verify that the chain of the crane remains under slight tension. If the tension is too strong, impermissible forces can be exerted on the Hexapod.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the Hexapod system.
- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the working space of the Hexapod.

NOTICE

Damage to the Hexapod power supply!

The Hexapod power supply can be damaged due to disturbed heat dissipation.

- Install the Hexapod power supply only with its bottom side (equipped with rubber feet) facing downwards.
- Place the Hexapod power supply in a location with adequate ventilation to prevent internal heat build-up.
- Allow at least 15 cm clearance from the front and the rear of the unit and 1 cm from the bottom (ensured by the feet of the chassis).
- Never cover any ventilation openings as this will impede ventilation.

INFORMATION

The optionally available PIVeriMove software for collision checking can be used to mathematically check possible collisions between the Hexapod, the load and the environment. The use of the software is recommended when the Hexapod is located in a limited installation space and/or operated with a spatially limiting load. For details regarding the activation and configuration of the PIVeriMove software for collision checking, see Technical Note C887T0002 (included in the scope of delivery of the software).

5.2 Determining the Permissible Load and Working Space

Tools and accessories

- PC with Windows operating system on which the simulation program Hexapod Simulation Software is installed. For more information, see the manual of the Hexapod controller.

Determining the working space and permissible load of the Hexapod

➢ Follow the instructions in the manual of the Hexapod controller to determine the working space and the limit value for the load of the Hexapod with the simulation program.

The limit values in the following table are for orientation. They apply when the center of mass is at or when the gravital forces are exerted on the origin of the XYZ coordinate system (0,0,0).
The limit values are given for horizontal mounting and for any orientation.

	Servo mode switched on for Hexapod – Max. load capacity		**Servo mode switched off for Hexapod – Max. holding force**	
Mounting position of the base plate	Mounted horizontally	Any orientation	Mounted horizontally	Any orientation
Hexapod	1000 kg	300 kg	10000 N	3000 N

If you need help in determining the limit value for the load or determining the working space:

➢ Contact our customer service department (p. 57).

5.3 Attaching the Snap-On Ferrite Suppressors

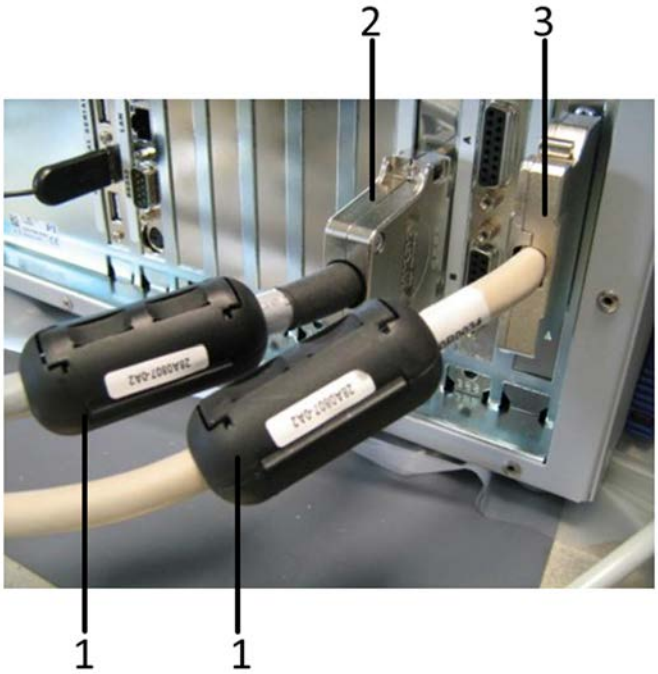


Figure 17: Proper location of snap-on ferrite suppressors

1 Snap-on ferrite suppressor 000045400

2 Connector of data transmission cable for brakes, limit switches and system status, sub-D25 (m) (controller side)

3 Connector of data transmission cable, MDR68 (m) (controller side)

INFORMATION

Two snap-on ferrite suppressors 000045400 are included in the scope of delivery of the Hexapod system. Both snap-on ferrite suppressors are for permanent attachment: one snap-on ferrite suppressor is for the I/O data cable connection for signals of brakes, limit switches and system status. The other snap-on ferrite suppressor is for the other data cable.
The snap-on ferrite suppressors ensure the electromagnetic compatibility of the Hexapod system.

➢ Attach each snap-on ferrite suppressor to the corresponding cable at the controller side before you connect the Hexapod to the Hexapod controller for the first time.

Tools and accessories

- 2 snap-on ferrite suppressors 000045400, in the scope of delivery (p. 14)

Permanently attaching the snap-on ferrite suppressors

1. Place the K040B0088 data transmission cable close behind the MDR68 (m) connector, that is intended for connection to the controller, into the opened snap-on ferrite suppressor (see Figure 17).
2. Close the snap-on ferrite suppressor:
   a) Align the cable so that it is not squeezed when the snap-on ferrite suppressor is closed.
   b) Carefully press the two halves of the snap-on ferrite suppressor around the cable until the lock engages.
3. Place the K040B0430 data transmission cable for brakes, limit switches and system status close behind the sub-D25 (m) connector, that is intended for connection to the controller, into the opened snap-on ferrite suppressor (see Figure 17).
4. Repeat step 2 for the second snap-on ferrite suppressor.

5.4 Mounting the Hexapod on a Surface

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the Hexapod.

- ➢ Only transport the Hexapod using a crane. The crane must lift the Hexapod by 3 ring bolts and shackles affixed to the Hexapod.
  You have two options to fix the ring bolts and shackles:
  - – Recommended:
    Use the 3xM12 mounting holes with a depth of 24 mm of the moving platform of the Hexapod as labeled in Figure 14 on p. 24.
  - – Use the 3xM12 mounting holes with a depth of 50 mm of the base plate of the Hexapod, see Figure 31 on p. 66.
- ➢ Hold the Hexapod only by the base plate to position it on a surface..

NOTICE

With base plate affixing to crane: Damage due to chains of crane!

When the base plate of the Hexapod is affixed to the crane the chains of the crane can cause damage to the Hexapod.

- ➢ Only affix the base plate of the Hexapod to the crane with a suitable crane set-up that prevents the chains of the crane from exerting impermissible forces on the Hexapod.
  The chains of the crane must **not** touch the struts and the moving platform of the Hexapod.

NOTICE

Warping of the base plate!

Incorrect mounting can warp the base plate. Warping of the base plate reduces the accuracy.

- ➢ Mount the Hexapod on an even surface. The recommended evenness of the surface is 100 µm.

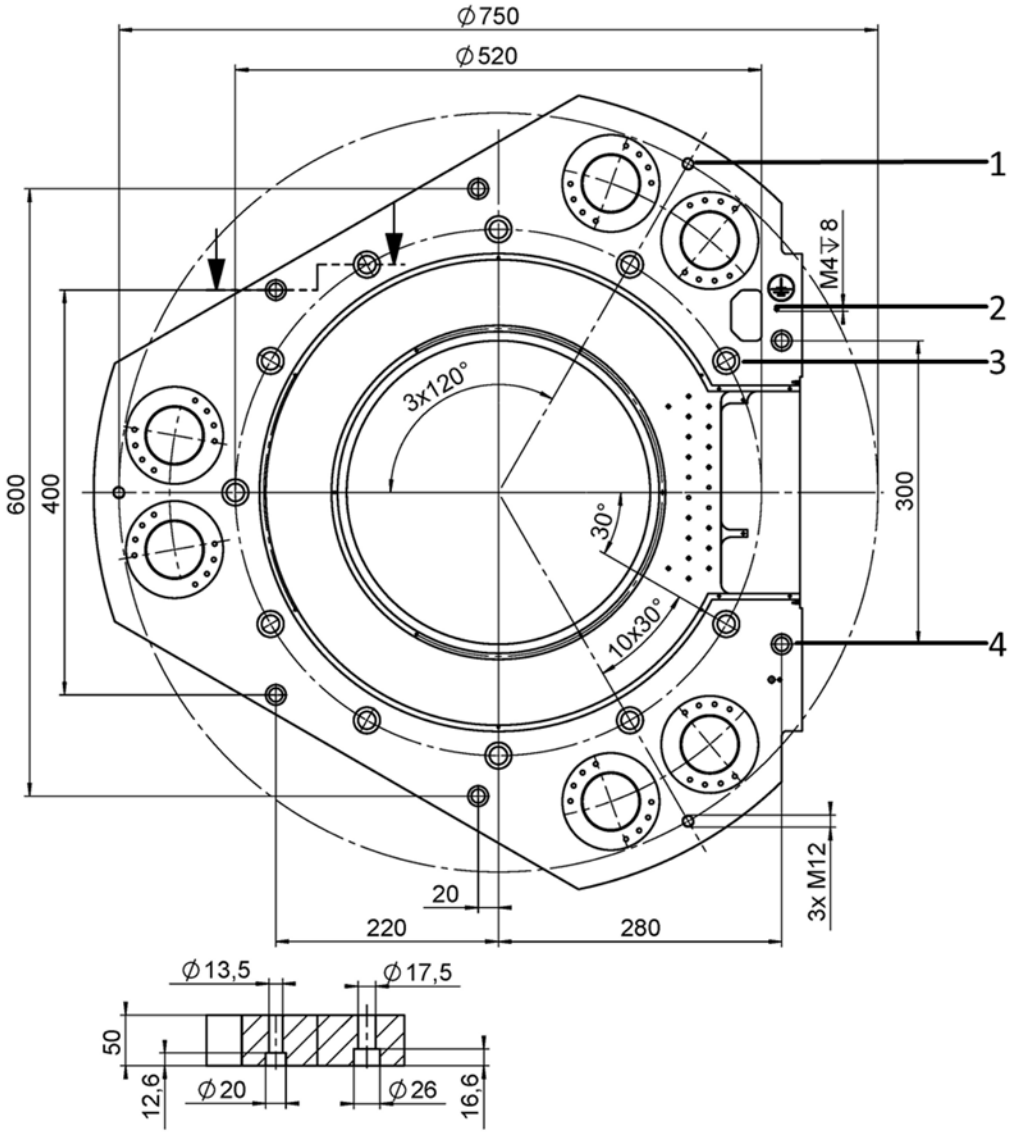


Figure 18: Mounting holes in the base plate

1 3 x M12 through holes with 50 mm depth
2 M4 screw for grounding
3 11 x Counterbore holes with Ø 17.5 mm for M16
4 6 x Counterbore holes with Ø 13.5 mm for M12

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 27).
- ✓ If possible: Position the surface where the Hexapod is to be mounted horizontally.
- ✓ You have connected the Hexapod to a crane via 3 ring bolts and shackles as described in “Unpacking” (p. 21)

Tools and accessories

- Allen wrench 10.0 and six of the supplied screws (p. 14).
- Optional: 11 M16x60 screws, suitable for holes with Ø 17.5 mm, not included in the scope of delivery

Mounting the Hexapod

1. Make the necessary holes in the surface:
   - 6 counterbore holes with Ø 13.5 mm for mounting with M12x60 screws, see figure above.
   - Optional: 11 counterbore holes with Ø 17.5 mm for M16x60 screws

     The arrangement of the six mounting holes as well as the 11 mounting holes with Ø 17.5 mm in the base plate of the Hexapod can be found in the figure above.
2. Lift the Hexapod to a suitable height.
3. Align the Hexapod to the surface.
   Note: The front side of the Hexapod with the connections to controller and power supply is perpendicular to the negative motion direction of the X axis (p. 64).

   When the Hexapod is to be mounted on a tilted surface:
   - Verify that the Hexapod is lifted by the crane without the Hexapod slipping from the tilted surface in a sudden motion.
   - Verify that the chain of the crane remains under slight tension. If the tension is too strong, impermissible forces can be exerted on the Hexapod.
4. Mount the Hexapod on the six counter-sunk holes with Ø 13.5 mm in the base plate using the included screws.
5. Disconnect the three shackles from the crane.
6. Remove the three shackles from the ring bolts.

7. Remove the three ring bolts from the three M12 mounting holes in the moving platform of the Hexapod.

5.5 Grounding the Hexapod

If a functional grounding is required for potential equalization you can ground the Hexapod either via the power supply cable or you can proceed as follows:

1. Connect the base plate to the grounding system:
   - For connection, use the supplied accessories (p. 14) and the M4 hole marked with the ground connection symbol, see dimensional drawing (p. 64).
2. Connect the moving platform to the grounding system:
   - Use one of the mounting holes in the moving platform (p. Figure 19) for connection.
     or
   - If the moving platform and the load are conductively connected with each other, connect the load to the grounding system.

5.6 Affixing the Load to the Hexapod

NOTICE

Impermissible mechanical load and collisions!

Impermissible mechanical load and collisions between the Hexapod, the load to be moved, and the surroundings can damage the Hexapod.

- ➢ Make sure that the installed load observes the limit value resulting from the load test (p. 29).
- ➢ Avoid high forces and torques on the moving platform during installation.
- ➢ Make sure that no collisions between the Hexapod, the load to be moved, and the surroundings are possible in the working space of the Hexapod.

NOTICE

Screws that are too long!

The Hexapod can be damaged by excessively long screws.

- When selecting the screw length, observe the thickness of the moving platform or the depth of the mounting holes (p. 64) together with the load to be mounted.
- Only use screws that do not project under the moving platform after being screwed in.
- Only mount the Hexapod and the load on the mounting fixtures (holes) intended for this purpose.

NOTICE

Excessive torque on Hexapod!

When the 3xM20 through holes are used for mounting a load an excessive torque may result on the Hexapod and cause damage.

- When a load is to be mounted with the 3xM20 through holes use the simulation program Hexapod Simulation Software for the following:
  - Check the values of the tightening torque of the screws for safe mounting of the load
  - Select appropriate screws and load to ensure that the maximum torque and the maximum load capacity is observed.

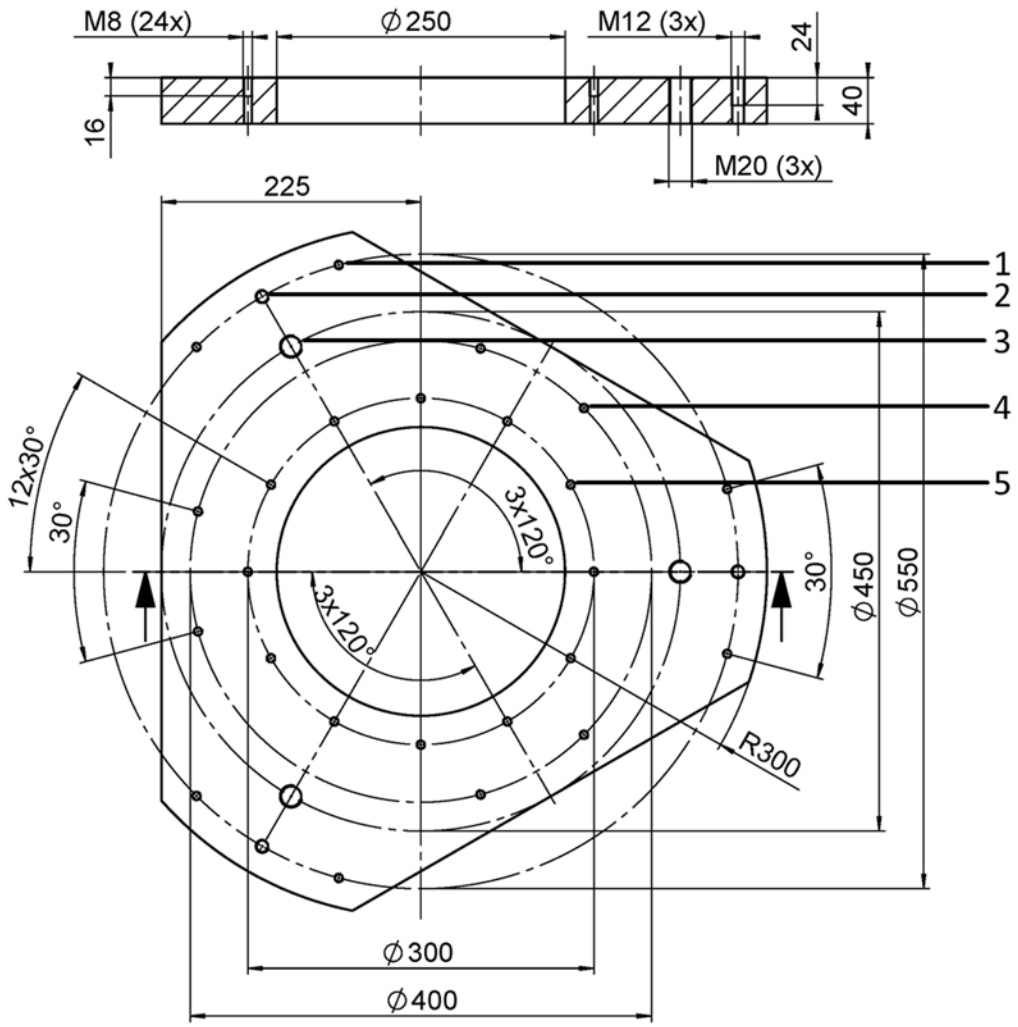


Figure 19: Mounting holes in the moving platform

1 *6 x M8 through holes with 16 mm depth of thread, in a radius of 550 mm*
2 *3 x M12 through holes with 24 mm depth of thread, in a radius of 550 mm*
3 *3 x M20 through holes, in a radius of 450 mm (not to be used)*
4 *6 x M8 through holes with 16 mm depth of thread, in a radius of 400 mm*
5 *12 x M8 through holes with 16 mm depth of thread, in a radius of 300 mm*

Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 27).
- ✓ You have determined the permissible load and the working space of the Hexapod (p. 29).
- ✓ You have designed the load and the environment of the Hexapod so that the permissible load of the Hexapod is observed and no collisions can occur.

Tools and accessories

- Suitably long screws. Options:
  - Up to 24 M8 screws, depending on load and mass distribution
  - 3 M12 screws
- Suitable tools for fastening the screws

Affixing the Load

1. Align the load so that the selected mounting holes in the moving platform can be used for affixing it.
   Note: The front side of the Hexapod with the connections to controller and power supply is perpendicular to the negative motion direction of the X axis, see the dimensional drawing (p. 64).
2. Affix the load to the selected mounting holes in the moving platform using the screws.

5.7 Connecting Cable Set and Power Supply to the Hexapod

Prerequisites

- ✓ The cable set is **not** connected to the Hexapod controller.
- ✓ The power supply of the Hexapod is switched off.

Tools and accessories

- Cable set that belongs to the Hexapod system (p. 9)
- Power supply that belongs to the Hexapod system (p. 9)

Connecting cable set and power supply to the Hexapod

1. Connect the data transmission cable with the MDR68 connector to the **Controller** MDR68 socket in the base plate of the Hexapod:

a) Press the latches together on both sides of the connector.
b) Insert the connector into the socket on the Hexapod.
c) Check that the connector correctly fits.
d) Release the latches.

2. Connect the data transmission cable with the sub-D25 coupling to the **Digital I/O** sub-D25 panel plug, in the base plate of the Hexapod.
3. Connect the sub-D3W3 coupling of the power supply cable to the **24 VDC** sub-D3W3 panel plug, in the base plate of the Hexapod.
   – Do not use force.
4. Connect the sub-D3W3 connector of the power supply cable to the **Power Out1** socket of the power supply.

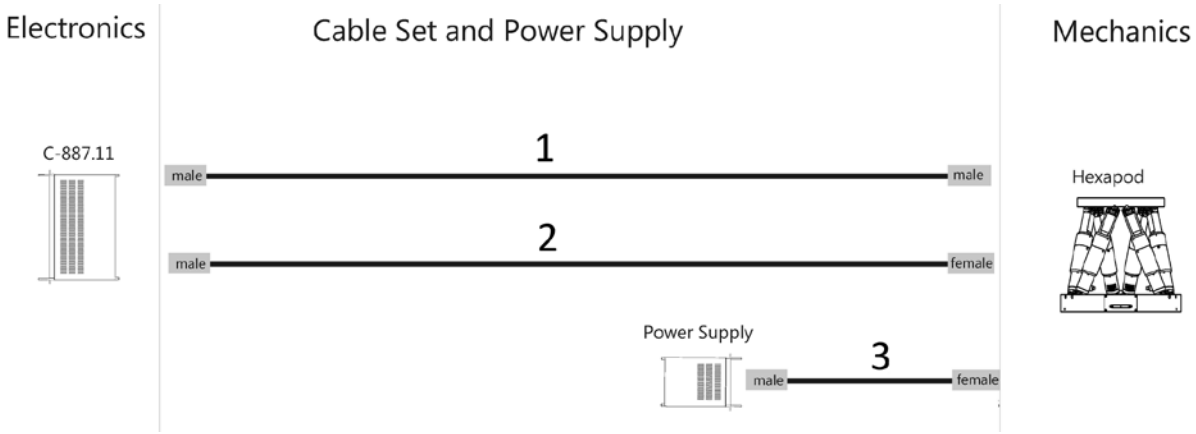


Figure 20: Connection diagram for cable set

1	*K040B0088*	*Data transmission cable, MDR68m to MDR68m, 9 m*
2	*K040B0430*	*Data transmission cable for brakes, limit switches and system status, sub-D25m (controller side) to sub-D25f (Hexapod side), 9 m*
3	*K060B0140*	*Power supply cable, sub-D3W3m (power supply side) to sub-D3W3f (Hexapod side), 3 m*

6 Start-Up

In this Chapter

General Notes on Start-Up 41
Starting Up the Hexapod System 43
Switching Off the Hexapod System 44

6.1 General Notes on Start-Up

CAUTION

Risk of crushing by moving parts!

There is a risk of injuries caused by crushing which can occur between the moving parts of the Hexapod and a stationary part or obstacle.

➢ Keep any part of your body away from areas where they can get caught by moving parts.

NOTICE

Output voltage of Hexapod power supply too high!

The Hexapod controller checks if the output voltage of the Hexapod power supply is in the permissible range. When the output voltage exceeds the upper limit of the permissible range, the struts of the Hexapod can be damaged.

Exceeding the upper limit of the permissible output voltage range is indicated as follows:

- The Hexapod controller beeps constantly.
- An error code is set.
- The **Status** LED of the Hexapod glows red.

➢ When the permissible output voltage range is exceeded, switch off the Hexapod power supply immediately and contact our customer service department (p. 57).

NOTICE

Incorrect configuration of the Hexapod controller!

The configuration data used by the Hexapod controller (e.g. geometrical data and servo-control parameters) must be adapted to the Hexapod. If incorrect configuration data is used, the Hexapod can be damaged by uncontrolled motions or collisions. The configuration data is adapted before delivery.

- ➢ Check whether the Hexapod controller matches the Hexapod. A label on the rear panel of the controller indicates for which Hexapod the controller is intended.
- ➢ When you have established the communication via TCP/IP or RS-232 or use the user interface of the C-887, send the `CST?` command. The response shows the Hexapod to which the controller is adapted.
- ➢ Only operate the Hexapod with a Hexapod controller whose configuration data is adapted to the Hexapod.

NOTICE

Damage from collisions!

Collisions can damage the Hexapod, the load to be moved and the environment.

- ➢ Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.
- ➢ Do not place any objects in areas where they can get caught by moving parts.
- ➢ If the Hexapod controller malfunctions, stop the motion immediately.

INFORMATION

The **Status** LED of the Hexapod glows red when the limit switches of the Hexapod struts are activated or when the Hexapod controller has the servo mode switched off. In order to deactivate the limit switches and to switch on the servo mode, a successful reference move of the Hexapod is required.

1. Start up the Hexapod system (p. 43). Start-up also includes a reference move (see user manual of the Hexapod controller).
2. If the **Status** LED remains red and/or the reference move is not successfully performed: Contact our customer service department (p. 57).

INFORMATION

When the output voltage of the Hexapod power supply falls below the lower limit of the permissible range, the **Status** LED glows red and motion commands are not performed to protect the Hexapod from impermissible forces. An error code is only set when the servo mode of the Hexapod controller is activated.

➢ Check the power supply and observe the permissible load and workspace (p. 29).

INFORMATION

The output voltage of the Hexapod power supply is deactivated automatically when the internal temperature sensor detects temperatures above 70 °C.

1. Wait a few minutes to let the power supply cool down.
2. Switch the power supply off and on again.

6.2 Starting Up the Hexapod System

INFORMATION

The brakes of the Hexapod are activated when the Hexapod controller has the servo mode switched off. The servo mode is switched off in the following cases:

- Hexapod controller is switched off
- Hexapod controller is rebooting
- Servo mode is switched off by an SVO command; for command description see the user manual of the C-887 Hexapod controller
- The allowable position error of a strut is exceeded.
- At least one of the limit switches of a strut is activated.
- The output voltage of the Hexapod power supply is below or above the permissible output voltage range.
- The Hexapod power supply is switched off.

INFORMATION

The cube on the base plate (item 8 of Figure 1 on p. 11) visualizes the orientation of the coordinate system.

This can be useful, for example, to visualize a motion of the Hexapod when the Hexapod base plate is mounted other than horizontal.

Prerequisite

- ✓ You have read and understood the General Notes on Start-Up (p. 41).
- ✓ You have correctly installed the Hexapod and the Hexapod power supply according to the instructions in "Installation" (p. 27).
- ✓ You have read and understood the user manual of the Hexapod controller.

Accessories

- Hexapod controller belonging to the Hexapod system
- PC with suitable software (see user manual of the Hexapod controller)

Starting up the Hexapod system

1. Connect the Hexapod to the Hexapod controller (see user manual of the Hexapod controller).
2. Connect the supplied power cord to the panel plug in the rear panel of the Hexapod power supply.
3. Connect the Hexapod power supply to the power socket with the power cord.
4. Switch on the Hexapod power supply by moving the power switch into the ▬ position.
5. Start up the Hexapod controller (see user manual of the Hexapod controller).
6. Operate a few motion cycles for testing purposes (see user manual of the Hexapod controller).

6.3 Switching Off the Hexapod System

1. Switch off the Hexapod controller.
   Thus the servo mode is switched off and the brakes are activated.
2. Switch off the Hexapod power supply by moving the power switch into the ○ position.

7 Maintenance

In this Chapter

Carrying out a Maintenance Run 45
Packing the Hexapod for Transport 46
Replacing the Fuses of the Hexapod Power Supply 51
Cleaning the Hexapod 51

NOTICE

Damage due to improper maintenance!

The Hexapod can become misaligned as a result of improper maintenance. The specifications can change as a result (p. 59).

- Do not loosen any screws.

Depending on the operational conditions and the period of use of the Hexapod, the following maintenance measures are required.

7.1 Carrying out a Maintenance Run

Frequent motions over a limited travel range can cause the lubricant to be unevenly distributed on the spindle.

- Carry out a maintenance run over the entire travel range at regular intervals (see user manual of the Hexapod controller). The more often motions are carried out over a limited travel range, the shorter the time between the maintenance runs has to be.

7.2 Packing the Hexapod for Transport

CAUTION

Crushing hazard!

Depending on the tilting angle of the surface to which the Hexapod is mounted, the Hexapod can slip, tilt or fall from the surface. There is a risk of injuries if parts of your body get caught by the Hexapod, and the Hexapod can be damaged.

- ➢ Position the surface where the Hexapod is mounted horizontally.

If the surface where the Hexapod is mounted cannot be positioned horizontally:

- ➢ Keep any part of your body away from areas where they can get caught by the Hexapod.
- ➢ Loosen the screws with which the Hexapod is mounted on the surface only when the Hexapod is connected to the crane by the three ring bolts and shackles.

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the Hexapod.

- ➢ Only send the Hexapod in the original packaging.
- ➢ Only transport the Hexapod using a crane. The crane must lift the Hexapod by 3 ring bolts and shackles affixed to the Hexapod.
  You have two options to fix the ring bolts and shackles:
  - Recommended:
    Use the 3xM12 mounting holes with a depth of 24 mm of the moving platform of the Hexapod as labeled in Figure 21 on p. 48.
  - Use the 3xM12 mounting holes with a depth of 50 mm of the base plate of the Hexapod, see Figure 31 on p. 66.

NOTICE

With base plate affixing to crane: Damage due to chains of crane!

When the base plate of the Hexapod is affixed to the crane the chains of the crane can cause damage to the Hexapod.

- ➢ Only affix the base plate of the Hexapod to the crane with a suitable crane set-up that prevents the chains of the crane from exerting impermissible forces on the Hexapod.
  The chains of the crane must **not** touch the struts and the moving platform of the Hexapod.

NOTICE

Sudden, impermissible forces during demounting Hexapod from tilted surface!

When the Hexapod slips from a tilted surface while it is connected to the crane, impermissible forces can occur which can cause damage to the Hexapod.

➢ Position the surface where the Hexapod is mounted horizontally.

If the surface where the Hexapod is mounted cannot be positioned horizontally:

➢ Lift the crane carefully while loosening the screws with which the base plate of the Hexapod is mounted to the surface.

Prerequisites

- If possible: You have positioned the surface where the Hexapod is mounted horizontally.

Accessories

- Original packaging, including pallet, cardboard box and hard foam inserts
- 3 ring bolts of appropriate size
- 3 shackles of appropriate size
- Crane appropriate to carry a load of 120 kg

Packing the Hexapod for transport

1. Command the Hexapod to move to the reference position:
   X = Y = Z= U = V = W= 0
2. Prepare to uninstall the Hexapod system.
   e) Power down the Hexapod controller.
   f) Switch off the Hexapod power supply.
   g) Remove the load from the moving platform of the Hexapod.
   h) Remove the two data transmission cables and the power supply cable from the Hexapod controller, the Hexapod power supply and the Hexapod.

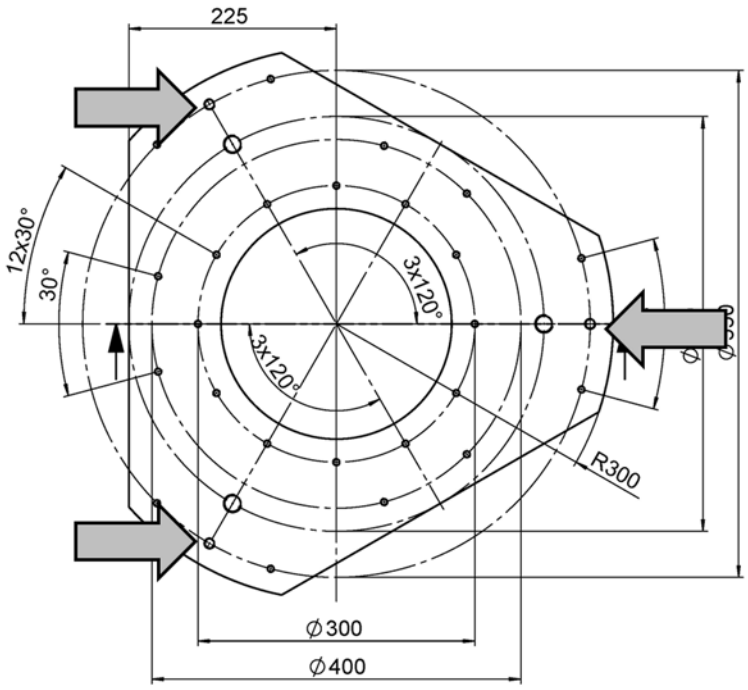


Figure 21: Top view on Hexapod, the arrows mark the three M12 mounting holes with 24 mm depth to be used for transport

3. Fix three ring bolts to the three M12 mounting holes with 24 mm depth in the moving platform of the Hexapod, see figure above.
4. Connect each ring bolt with a shackle.

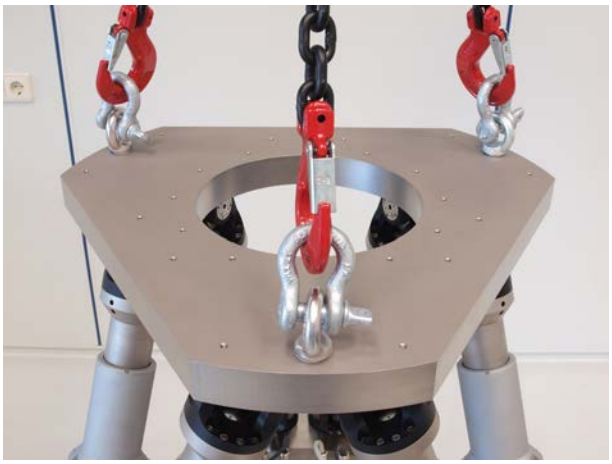


Figure 22: Lifting the Hexapod at its moving platform using three ring bolts and three shackles

5. Connect the shackles to the corresponding load interfaces of the crane, see figure above.
   Verify that the chain of the crane is only **slightly** under tension. If the tension is too strong, impermissible forces can be exerted on the Hexapod in the next step.
6. Uninstall the Hexapod from the surface to which it is mounted:
   – When the Hexapod is mounted on a tilted surface: Carefully lift the Hexapod by the crane during the uninstalling procedure so that the chain of the crane remains under tension and the Hexapod cannot slip in a sudden motion.

   a) Loosen the screws with which the Hexapod is mounted on the surface.
   b) Remove the screws.

Figure 23: Lifting the Hexapod by a crane

7. If required lift the Hexapod to a suitable height, see figure above.
8. Pack the Hexapod in a plastic foil to protect it against dirt.
   It is recommended to reuse compound foil in which the Hexapod was delivered.

9. Place the hard foam insert for the base plate of the Hexapod on the pallet.

Figure 24: Hexapod wrapped in foil, with lower hard foam insert on a pallet

10. Place the Hexapod into the hard foam insert on the pallet, see figure above.

Figure 25: Hexapod package with surrounding cardboard box

11. Place the cardboard box around the Hexapod, see figure above.

Figure 26: Hexapod package without cardboard lid

12. Insert the hard foam insert for the moving platform of the Hexapod in the cardboard box, see figure above.
13. Close the cardboard box with the cardboard lid.
14. Secure the box on the pallet.

7.3 Replacing the Fuses of the Hexapod Power Supply

NOTICE

Damage of power supply!

The Hexapod power supply can be damaged if unsuitable fuses are used.

➢ Check and replace **both** fuses if there is a fault.

Figure 27: Location of fuses at the rear panel of the Hexapod power supply

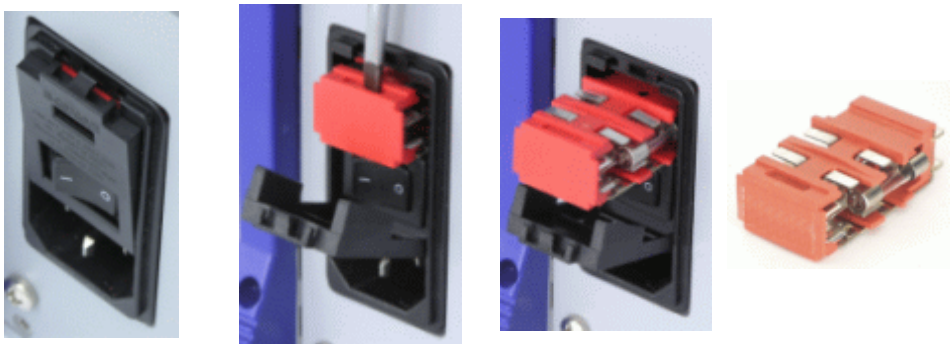


Figure 28: How to exchange fuses

Tools and accessories

- A suitable tool to pry open the fuse carrier

Replacing the fuses of the Hexapod power supply

1. Switch off the Hexapod power supply.
2. Disconnect the Hexapod power supply from the power socket by pulling the power plug.
3. Wait a minute to be sure that any residual voltage has dissipated.
4. Pry open the door that covers the fuse carrier and pry out the fuse carrier (see Figure 28 above).

5. Be sure to replace both fuses with fuses of the suitable type:

   100 to 240 V ~: 2 x IEC T 8 AL (with 250 V rated voltage)

   L = Low breaking
   T = Time lag

   Note that IEC fuses are cited: other fuse standards may require higher nominal current rating.

6. Reinstall the carrier and close the door

7.4 Cleaning the Hexapod

Prerequisites

✓ You have disconnected the Hexapod from the Hexapod power supply.

Cleaning the Hexapod

➢ When necessary, clean the Hexapod surface with a towel lightly dampened with a mild cleanser or disinfectant.

➢ Do not use any organic solvents.

8 Troubleshooting

Problem	Possible Causes	Solution
Controller beeps constantly and **Status** LED glows red	Output voltage of Hexapod power supply exceeds upper limit of permissible range	➢ Switch off the Hexapod power supply immediately. ➢ Contact our customer service department (p. 57).
System is not ready (**Status** LED glows red)	Output voltage of Hexapod power supply falls below lower limit of permissible range	When the output voltage is too low because the temperature of the power supply is above 50 °C: 1. Wait a few minutes to let the power supply cool down. 2. Switch the power supply off and on again.
	Hexapod power supply is switched off	➢ Switch on the Hexapod power supply.
	Servo mode is switched off	➢ Switch on the servo mode by sending an SVO command.
	At least one limit switch of a strut is activated	➢ Start a reference move by sending an FRF command.
	Impermissible load	➢ Observe the permissible load and work space (p. 29).
	Brakes remain closed	➢ Contact our customer service department (p. 57).
Reduced accuracy	Warped base plate	➢ Mount the Hexapod on an even surface (p. 30). The recommended evenness of the surface is 100 µm.
Increased wear	Only small motions over a long period of time	➢ Carry out a maintenance run over the entire travel range (p. 45).

One strut does not move or is difficult to move	▪ Wear of the spindle ▪ Foreign body has entered the spindle ▪ Faulty motor ▪ Blocked joint due to wear or foreign body ▪ At least one of the brakes is not deactivated by activating servo control	➢ Carry out a strut test (see user manual of the Hexapod controller). The strut test should be carried out in the reference position. Exception: the malfunction only occurs with maximum or minimum displacement of the platform in Z. ➢ Contact our customer service department (p. 57).

If the problem with your Hexapod is not listed in the table or it cannot be solved as described, contact our customer service department (p. 57).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (info@pi.ws).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

The latest versions of the relevant user manuals for your system are available for download on our website (http://www.pi.ws).

10 Technical Data

In this Chapter

Specifications 59
Ambient Conditions and Classifications 62
Dimensions of the Hexapod 64
Pin Assignment for the Hexapod 67

10.1 Specifications

10.1.1 Data Table of Hexapod

	Hexapod	Unit	Tolerance
	for higher loads and holding forces		
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X, Y	±110	mm	
Travel range* Z	±50	mm	
Travel range* θ_X, θ_Y	±15	°	
Travel range* θ_Z	±30	°	
Single-actuator design resolution	0.04	µm	
Min. incremental motion X, Y	1	µm	typ.
Min. incremental motion Z	0.5	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	10	µrad	typ.
Backlash X, Y	4	µm	typ.
Backlash Z	1	µm	typ.
Backlash θ_X, θ_Y	15	µrad	typ.
Backlash θ_Z	30	µrad	typ.
Repeatability X, Y	±2	µm	typ.
Repeatability Z	±1	µm	typ.
Repeatability θ_X, θ_Y, θ_Z	±10	µrad	typ.
Max. velocity X, Y, Z	20	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	50	mrad/s	

Typ. velocity X, Y, Z	10	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	30	mrad/s	
Mechanical properties			
Load (base plate horizontal / any orientation)	1000 / 300	kg	max.
Holding force, de-energized (base plate horizontal / any orientation)	10000 / 3000	N	max.
Motor type	Brushless DC motor		
Miscellaneous			
Operating temperature range	-10 to 50	°C	
Material	Aluminum alloy, stainless steel		
Mass	116	kg	±5%
Cable length to power supply	3	m	+10 / -0 cm
Cable length to controller	9	m	+50 / -0 cm
Mounting angle	0 to 360	°	

Technical data specified at 20±3°C, performance may be reduced outside this range.

* The travel ranges of the individual coordinates (X, Y, Z, θ_X, θ_Y, θ_Z) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.

10.1.2 Maximum Ratings of Hexapod

The Hexapod is designed for the following operating data:

Maximum Operating Voltage	Maximum Operating Frequency (Unloaded)	Maximum Power Consumption
24 V DC	⎓	500 W

10.1.3 Data Table of Hexapod Power Supply

	Hexapod Power Supply
Output voltage	24 V DC / 20 A max
Input voltage	110 – 230 V AC (50 – 60 Hz)
Input power	700 W
Output power	500 W
Fuses	2 x IEC T 8 AL (with 250 V rated voltage)
Dimensions	236 mm x 132 mm x 296 mm + handles
Mass	4.7 kg

10.1.4 Maximum Ratings of Hexapod Power Supply

The power supply is designed for the following operating data:

Maximum Operating Voltage	Maximum Operating Frequency (Unloaded)	Maximum Output Power
230 V AC	60 Hz	500 W

10.2 Ambient Conditions and Classifications

10.2.1 Ambient Conditions and Classifications for Hexapod

Degree of pollution:	2
Transport temperature:	–25 °C to +85 °C
Storage temperature:	-10 °C to 70 °C
Humidity:	Maximum relative humidity of 80% at temperatures of up to 31 °C, linearly decreasing until relative humidity of 50% at 40 °C
Degree of protection according to IEC 60529:	IP20
Area of application:	For indoor use only
Maximum altitude:	2000 m
Air pressure	1100 hPa to 0.1 hPa (corresponds to roughly 825 torr to 0.075 torr)

10.2.2 Ambient Conditions and Classifications for Hexapod Power Supply

Degree of pollution:	2
Transport temperature:	–25 °C to +85 °C
Storage temperature:	0 °C to 70 °C
Humidity:	Maximum relative humidity of 80% at temperatures of up to 31 °C, linearly decreasing until relative humidity of 50% at 40 °C
Degree of protection according to IEC 60529:	IP20
Area of application:	For indoor use only
Maximum altitude:	2000 m
Air pressure:	1013 hPa to 790 hPa (corresponds to roughly 760 torr to 592.5 torr)
Line voltage fluctuations:	Max. ±10 % of the line voltage
Overvoltage category:	II, transient overvoltages as typical for public power supply

10.3 Dimensions of the Hexapod

All figures show the Hexapod in the reference position. Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

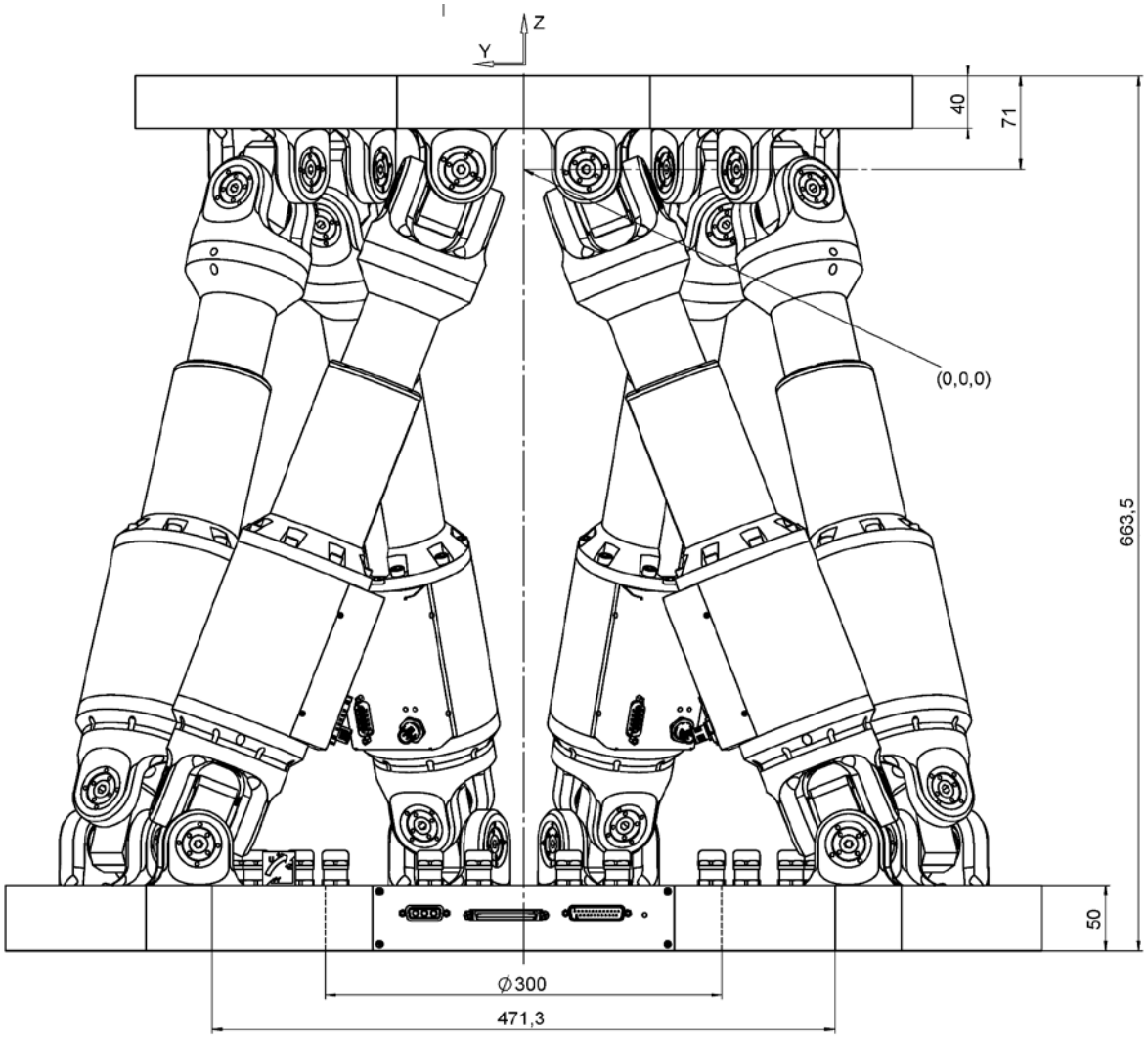


Figure 29: Hexapod front view (dimensions in mm)

The (0,0,0) coordinates refer to the origin of the XYZ coordinate system. When the default settings of the Hexapod controller are used and the Hexapod is in the reference position, the pivot point is located at the origin of the XYZ coordinate system.

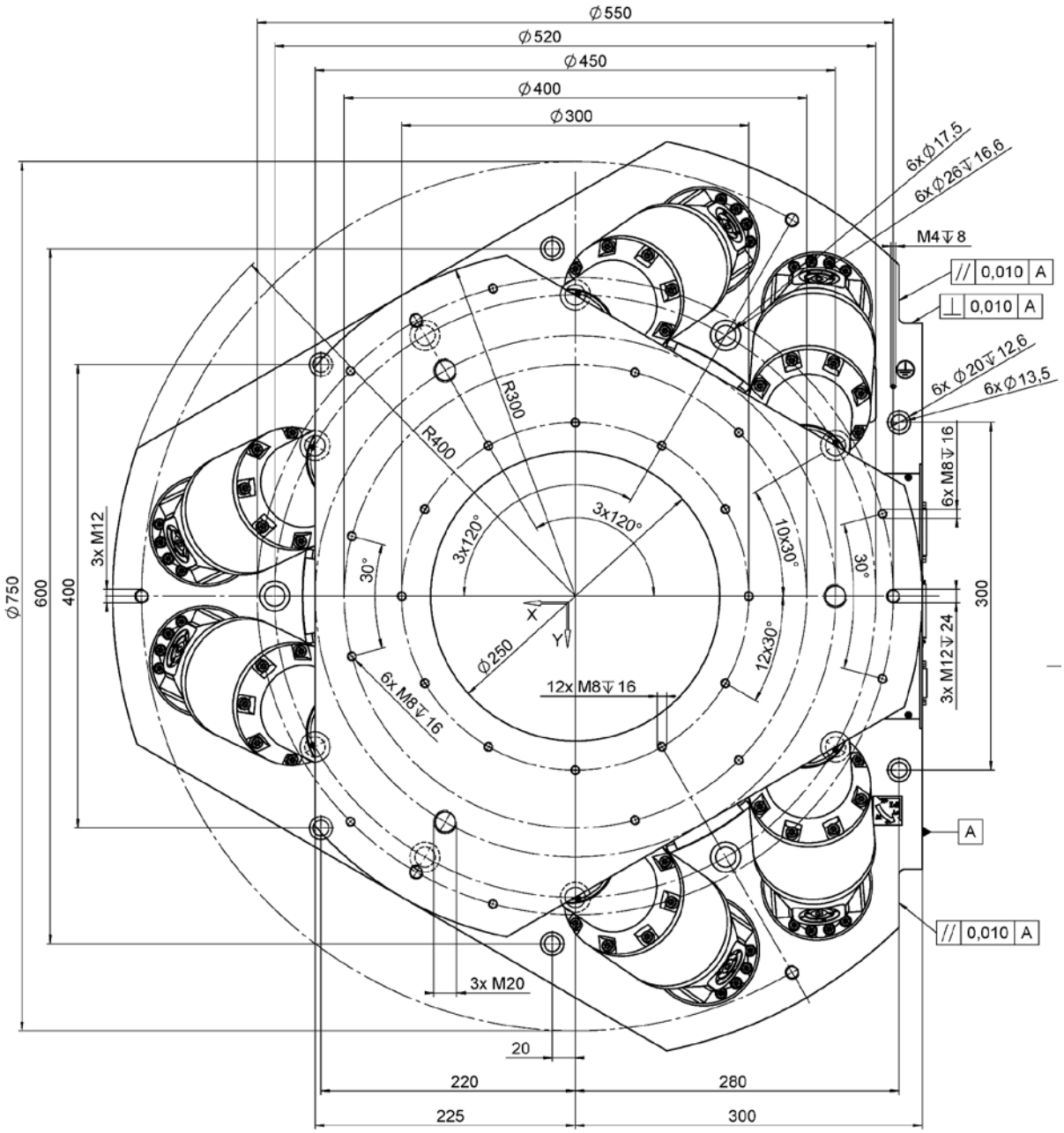


Figure 30: Hexapod top view (dimensions in mm)

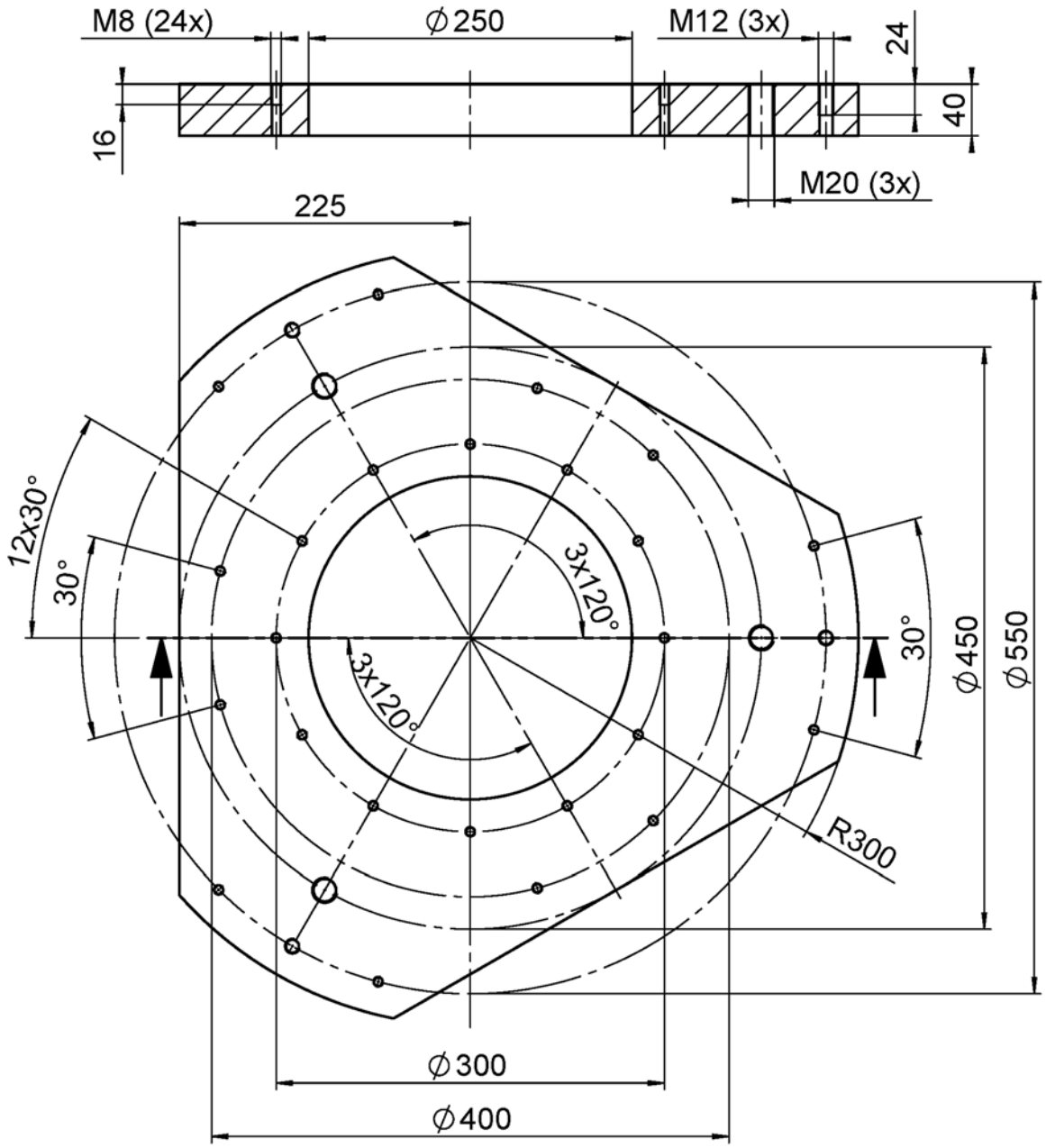
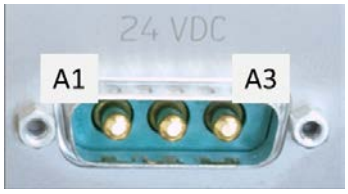


Figure 31: Base plate of Hexapod (dimensions in mm)

10.4 Pin Assignment for Hexapod

10.4.1 Power Supply Connection

Power supply between external power supply and Hexapod via sub-D3W3 panel plug at base plate of Hexapod

Pin	Function	
A1	GND	
A2	24 V DC	
A3	GND	
Shell	Shield	

10.4.2 Data Transmission Connection for Brakes, Limit Switches and System Status

Data transmission between the Hexapod and the Hexapod controller

Sub-D25 panel plug at base plate of Hexapod

Note: this pin assignment is also valid for the sub-D25(f) socket labeled **I/O** at the included Hexapod controller.

Pin	Function	Signal direction with respect to Hexapod	
1	GND	-	
2	Limit switch strut 2	Output	
3	GND	-	
4	Limit switch strut 5	Output	
5	GND	-	
6	Status information	Output	
7	GND	-	
8	Status LED	Input	
9	GND	-	
10	Not connected	-	

Pin	Function	Signal direction with respect to Hexapod	
11	GND	-	
12	Not connected	-	
13	GND	-	
14	Limit switch strut 1	Output	
15	Limit switch strut 3	Output	
16	Limit switch strut 4	Output	
17	Limit switch strut 6	Output	
18	Status information	Output	
19	Not connected	-	
20	Brakes	Input	
21	Not connected	-	
22	Not connected	-	
23	Not connected	-	
24	Not connected	-	
25	Not connected	-	

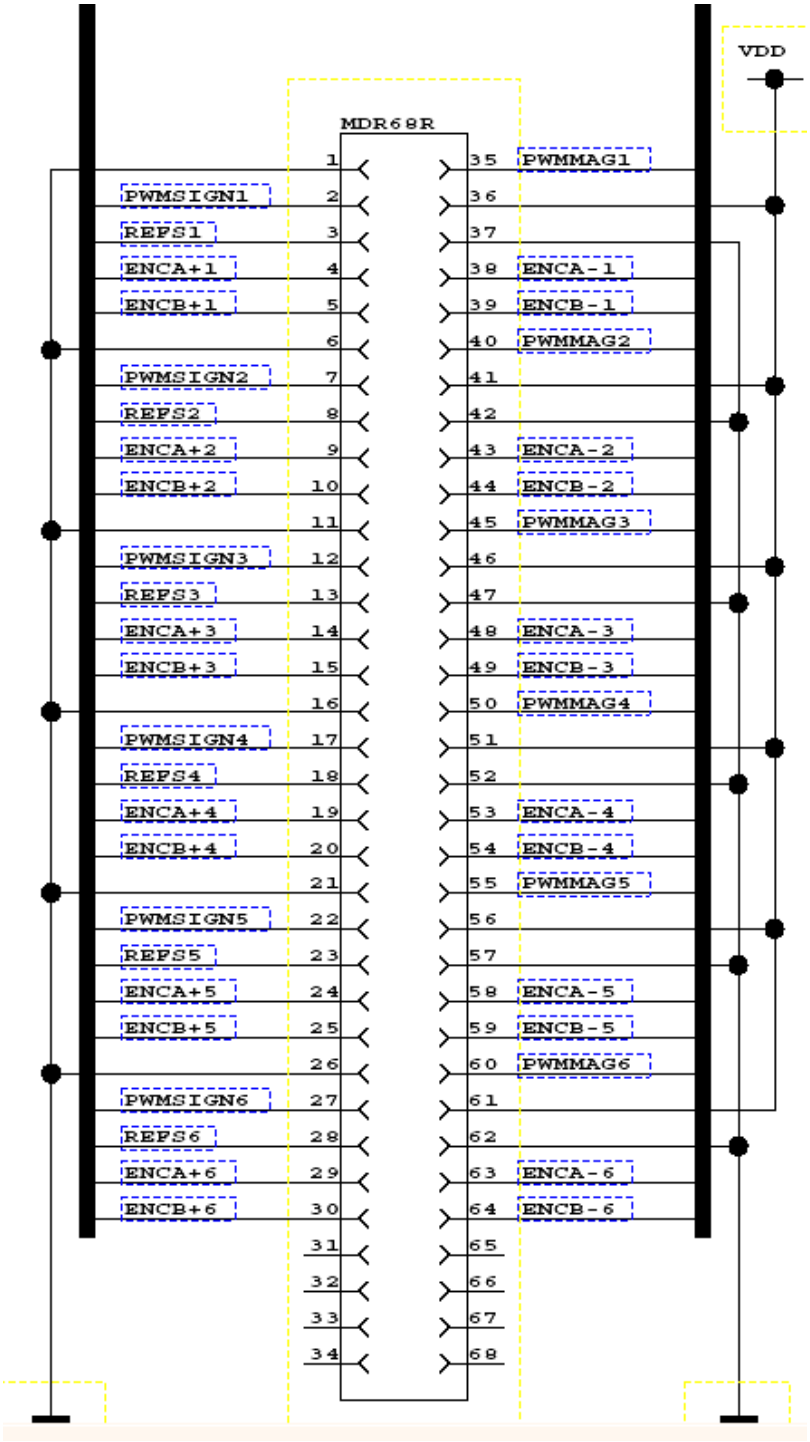
10.4.3 Data Transmission Connection

Data transmission between the Hexapod and the Hexapod controller

MDR68 socket at base plate of Hexapod

Function	Socket
All signals: TTL	

Pin assignment



11 Old Equipment Disposal

Since 13 August 2005, in accordance with the EU directive 2002/96/EC (WEEE), electrical and electronic equipment can no longer be disposed of in the member states of the EU with other wastes.

When disposing of your old equipment, observe the international, national and local rules and regulations.

To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstr. 1

D-76228 Karlsruhe, Germany

12 Glossary

Work space

The entirety of all combinations of translations and rotations that the Hexapod can approach from the current position is referred to as the work space.

The work space can be limited by the following external factors:

- Installation space
- Dimensions and position of the load

Pivot point

The rotation axes U, V and W meet at the pivot point. When the standard settings for the pivot point coordinates are used, the pivot point is located at the origin of the XYZ coordinate system after a reference move, see the dimensional drawing (p. 64) for more information.

The pivot point is shifted along with the platform during translations. Rotations do not change the position of the pivot point. The pivot point coordinates remain unchanged in both cases.

The pivot point coordinates can be changed in the Hexapod controller.

XYZ coordinate system

The position and orientation of the Cartesian XYZ coordinate system cannot be changed, which is why the system is referred to as spatially fixed. The axes X, Y and Z are referred to as translation axes.

The intersection of the axes of the spatially fixed Cartesian XYZ coordinate system (0,0,0) is referred to as the origin.

The Z axis is always perpendicular to the base plate of the Hexapod.

The following example figures of the H-810 Hexapod show that the XYZ coordinate system does not move along with motions of the platform.

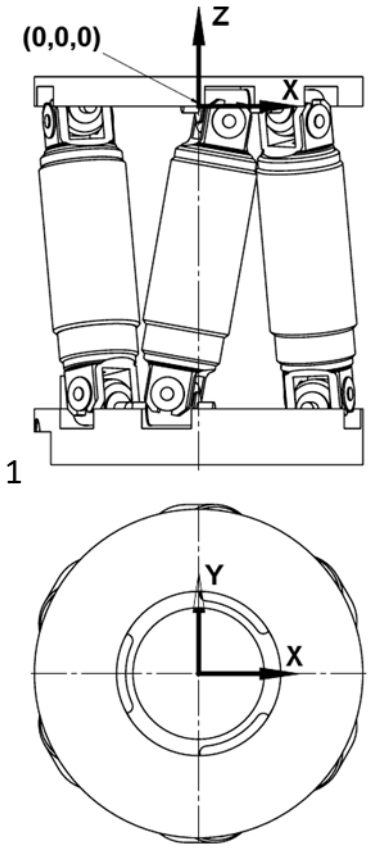


Figure 32: H-810 Hexapod in the reference position.

1 Cable outlet

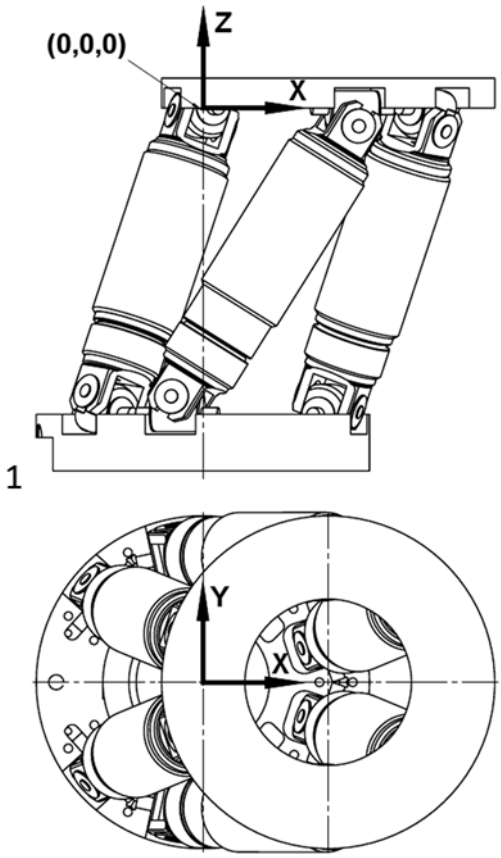


Figure 33: H-810 Hexapod, the platform of which has been moved in X.

1 Cable outlet

13 Appendix

13.1 Explanations of the Performance Test Sheet

The Hexapod is tested for the positioning accuracy of the translation axes before delivery. The performance test sheet is included in the scope of delivery.

The following figure shows the test setup used.

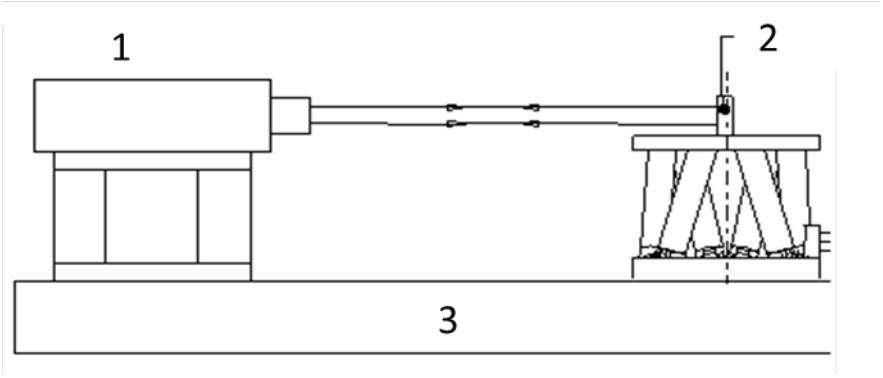


Figure 34: Test setup for measuring the X or Y axis.

2 Laser interferometer
3 Mirror
4 Bench

The following test cycles are performed:

- Movement over the entire travel range with at least 20 measuring points, in at least five cycles.
- Movement over partial sections, e. g. ±1 mm in increments of e. g. 10 µm

13.2 EC Declaration of Conformity

PI

Declaration of Conformity

according to DIN EN ISO/IEC 17050-1:2005

Manufacturer:	**Physik Instrumente (PI) GmbH & Co. KG**
Manufacturer's Address:	Auf der Roemerstrasse 1 D-76228 Karlsruhe, Germany

CE

The manufacturer hereby declares that the product

Product Name:	**High-Load Hexapod System**
Model Numbers:	**H-845.D11**
Product Options:	**all**

complies with the following European directives:

2006/42/EC, Machinery Directive
2006/95/EC, Low Voltage Directive (LVD)
2004/108/EC, EMC Directive
2011/65/EC, RoHS Directive

The applied standards certifying the conformity are listed below.

Safety of Machinery:	EN 12100:2010
Safety (Low Voltage Directive):	EN 61010-1:2010
Electromagnetic Emission:	EN 61000-6-3:2007, EN 55011:2009
Electromagnetic Immunity:	EN 61000-6-1:2007

The person authorized to compile the technical file is: Christian Rudolf
Address: see manufacturer's address

April 10, 2013
Karlsruhe, Germany

Norbert Ludwig
Managing Director

Physik Instrumente (PI) GmbH & Co. KG, Auf der Roemerstrasse 1, 76228 Karlsruhe, Germany
Phone +49 721 4846-0, Fax +49 721 4846-1019, E-mail info@pi.ws, www.pi.ws

PIEZO NANO POSITIONING